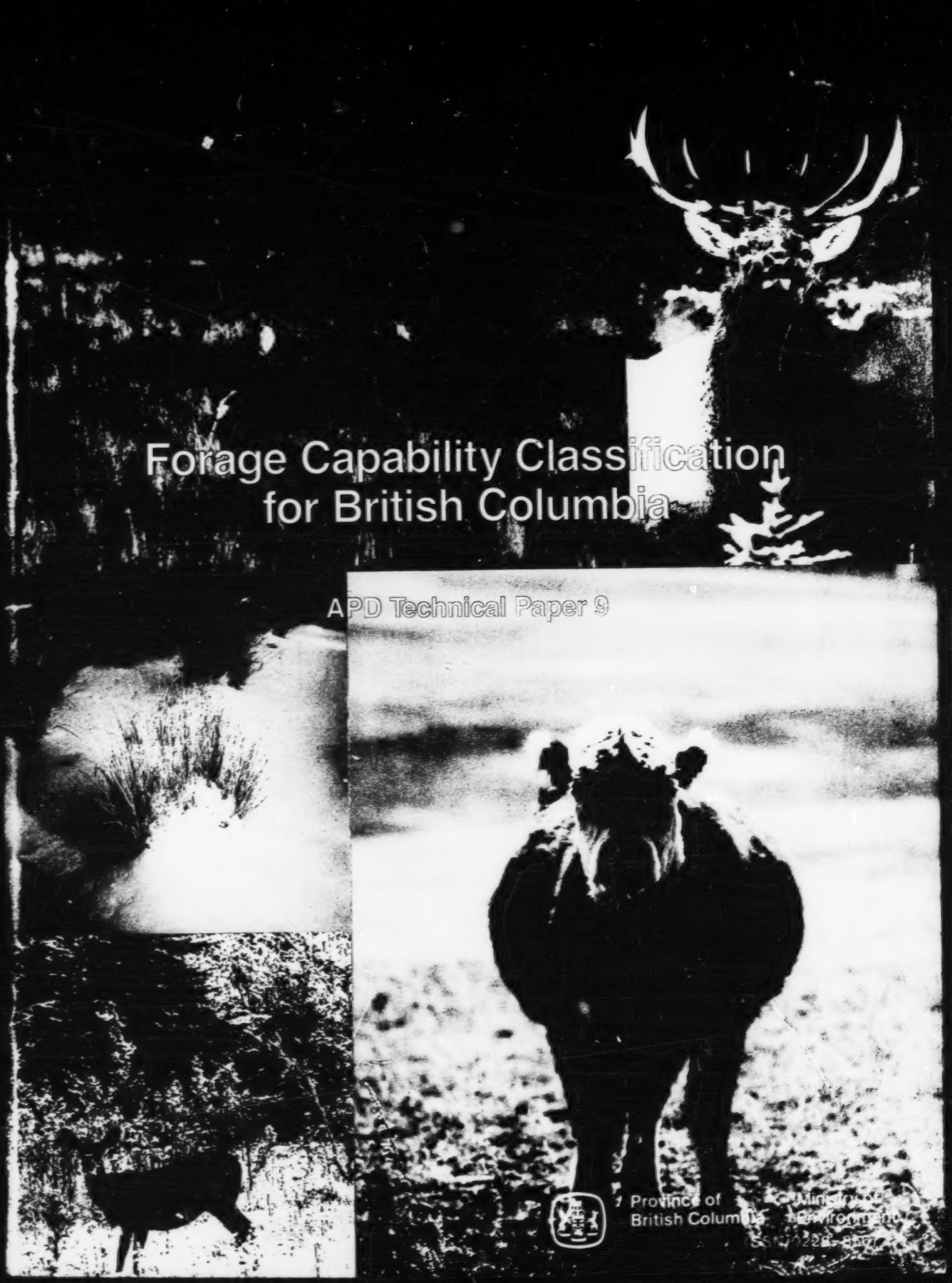

Forage Capability Classification for British Columbia

APD Technical Paper 9

Province of British Columbia

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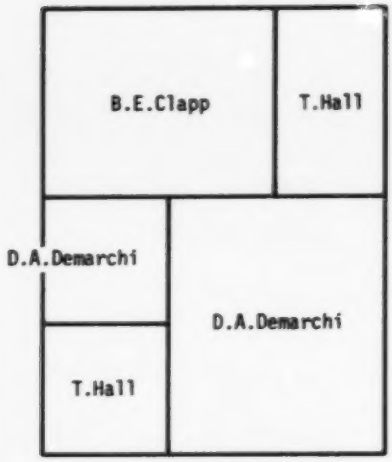

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Province of British Columbia
Ministry of Environment
ASSESSMENT AND PLANNING DIVISION

APD Technical Paper 9

FORAGE CAPABILITY CLASSIFICATION FOR BRITISH COLUMBIA:

A BIOPHYSICAL APPROACH

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PREFACE

The accompanying report is a proposal for the classification of forage potential for the province. It is intended that this system will generate information on herb, shrub and lichen production that will be comparable to information currently being collected for agricultural crops, forests, wildlife and recreation. This information will be useful in developing grazing and wildlife management programs of a regional and sub-regional nature.

Agreement in principle on this proposal was achieved in November 1978 by several professionals involved in rangeland classification. This methodology is designed for use in the field by resource agencies and individuals who are concerned with rangelands.

A need for a major review may be required in five years time. In order to determine this need, comments regarding ambiquities, ommissions or unfulfilled interpretation requirements should be documented and sent to D.A. Demarchi; Terrestrial Studies Branch, Ministry of Environment, Parliament Buildings, Victoria, B.C.

Grateful acknowledgement is extended to the following professionals who have been involved in this project: P.N. Sprout, A.H. Bawtree, J.E. Hilton, E. Kenk, T. Lester, A. McLean, W.R. Mitchell, B.A. Pendergast, R.V. Quenet, R.S. Silver, and J. van Barneveld.

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Chapter 1
INTRODUCTION

1.1 The Biophysical Program

It is the role of the Terrestrial Studies Branch of the Ministry of Environment to develop a classification that can be used for overall resource capability inventories and resource planning. The biophysical program provides an opportunity for the comparisons of all renewable resources occupying the same biological and physical resource land units.

The biophysical classification program is a building block process that encourages the synthesis of physical and biological data (landforms, surficial materials, soils, climate, vegetation and organisms) to form "ecologically significant" units of the landscape. The process involves the delineation of various regional and local environmental phenomena, each of which is an end point for the appropriate discipline, but when the information is combined, provides the basis of the biophysical map unit.

No inventory procedure offers a fixed measure of the status and value of resources for all time. However, the biophysical concept of inventory does identify the more permanent natural physical factors which define land units. It also offers the best basis for measuring renewable resource endowments,

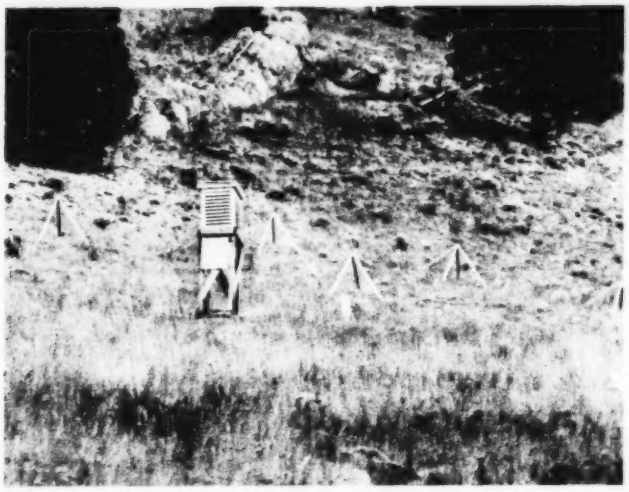

Plate 1. Many environmental parameters must be measured in order to assess the capability of an area to produce forage. Climatic parameters when measured at the same time as herb production can help account for year to year production differences due to weather variations.

Plate 2. Forage measurements recorded from one site must be related to other sites of similar biophysical character. The determination of surficial materials, terrain features and soil processes is necessary in order to make forage capability inferences between sites.

for appreciating resource relationships, and for assessing how these can be managed through various uses or combinations of uses.

Currently the biophysical units are used to rate land for its capability to provide or produce agricultural crops, forests, recreation and native ungulates (wildlife). It was our purpose to also develop a capability classification for rangelands by providing a system for rating native forage production potential, using the following definition: "Land-use capability is the potential of an area to produce a specified crop (in this case, herbs, shrubs and lichens) under specified technological controls. The level of production for forage is measured in terms of the amount of forage produced, given the kinds and degrees of limitations which prevent any specific land unit from reaching the maximum production" (Hills, et al., 1973).

1.2 Forage Classifications

Most range studies have been concerned with primary production of grasses and forbs as an estimation of range condition. While this production is an important end product of range evaluation for livestock production, it is not a complete forage classification in itself. Often any reference to wildlife forage requirements is commonly omitted. Also omitted are distinctions or relationships amongst herbage, browse and tree production within or among plant associations or even vegetation zones. Unit boundaries have been traditionally based on ephemeral differences in plant communities such as stand age rather than on more permanent features such as soil, surficial material, and/or landform.

Forage availability studies should account for time and space, two factors ignored by most range classifications. It is much easier to measure current standing crop than to estimate the potential range of production, and it is easier to study plant communities as a concept than to define and locate their boundaries. This classification rates biophysical units on their capability or potential to produce either herbage or shrubs or lichens. As such, the existing quantities are only of consequence if they are at optimum levels or if they can be used to extrapolate potential values. This information will satisfy the requirements of primary biomass identification and also supply information that can be applied to more than one class of animal.

Plate 3. In assessing the capability of a site to produce forage, livestock and wildlife should be excluded for many years. The construction of exclosure plots in representative plant communities is a useful tool in developing forage capability models.

Plate 4. A big sagebrush-needle and thread grass dominated site that has received excessive livestock grazing for several decades. This site is at a maximum shrub production level but far below its potential to produce herbage. Such sites should not be used to infer herbage potential.

Photo credit: Canada Department of Agriculture

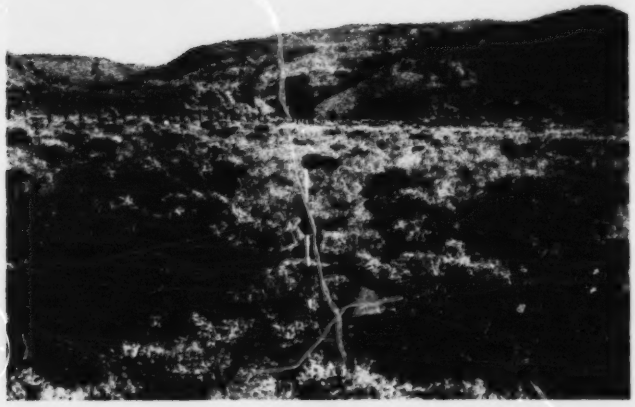

Plate 5. A big sagebrush-bluebunch wheatgrass dominated site that has been fenced from livestock grazing for several decades. This site is at a climax community stage.

Photo credit: Canada Department of Agriculture

Plate 6. Capability of a site to produce forage must account for past forage overuse. A fence that separates two different grazing regimes graphically illustrates the need to rate on site capability rather than on existing values if livestock and wildlife values are to be incorporated into a land use plan.

Chapter 2
FORAGE CAPABILITY CLASSIFICATION

2.1 The Classification

Forage can be defined as "all harvested and unharvested vegetation, except fruits of woody plants and harvested grains, that is available and acceptable to livestock or game animals" (U.S. Forest service, 1963). For the purpose of this forage capability classification, only native or wild growing introduced plant species are considered.

The forage capability classification defines the type and quantity of forage that can potentially grow on a unit of land. The unit used will be a biophysical unit that is assumed to be homogeneous[1] with respect to physical characteristics (e.g. soil, surficial material, climate, topography) and to be within a single vegetation landscape. A vegetation landscape is defined as a form of biophysical unit that represents landscape areas that are relatively homogeneous with regard to soils, surficial materials,

---

[1] A homogeneous plot should "usually contain a single soil polypedon and a single plant community, and be homogeneous with respect to environmental factors such as slope position, landform, texture, soil drainage, species composition or dominance, physiognomy, and stand structure" (Walmsley et al., 1980). However, due to a particular scale of mapping minor inclusions can be ignored. Also, a homogeneous unit may be a simple soil polypedon or a complex of soil polypedons which are well distributed throughout the plot.

disturbance history, climate, and macro vegetation (Lea, 1981). Each vegetation landscape may be divided into a number of successional stages[1], defined by plant community structure, plant competition relationships in the community, and dominant[2] plant species composition.

In applying a forage classification system, biophysical units (vegetation landscapes) that are nearly permanent[3] are necessary in order to have repeatability of data assessment in spite of changes within plant communities caused by such factors as fire, logging, forest succession, or overgrazing.

Three general assumptions are implied when a capability class is assigned. The classification is based on the "natural state" of the land without major improvements such as fertilization, drainage, irrigation, or introduction of exotic plant species. In a given capability class, location, access, distance to markets and size of units will not be considered. Access to water, salt, cover and other rangelands, while important to livestock and wildlife management, cannot be realistically appraised at this time and will not be considered in this classification.

---

1 Successional stage has also been referred to as "Ecological State" (Walmsley and van Barneveld, 1977; Lea, 1981).

2 Dominance refers to the taller plants of the community which are directly exposed to the local or regional (mesoclimate) atmospheric conditions. In a parkland community both the trees and the lower vegetation of the open spaces are considered dominant.

3 Only very extreme disturbance to the site would result in a change in the vegetation landscape (e.g. topsoil removal, or lowering the watertable).

Legends associated with forage capability maps should clearly define the particular successional stage within a vegetation landscape that is being classified. Without that information link, it is hard to determine which successional stage should be managed in order to produce maximum forage. In the case of herbage production in grassland or alpine environments, maximum productivity is probably in the climax stage of vegetation. For the forested environments maximum herbage production is probably some early stage of succession, after tree removal and prior to or in early stages of tree re-establishment. Shrub production may be high during pioneer seral stages on forested sites, though a shrub cover is often dominant in climax stages on wetlands and floodplains. Terrestrial lichen production is usually maximized in climax alpine tundra; and arboreal lichen production is maximized in climax conifer forest stands.

Forage components must include all plant species which may be utilized as food - lichens, herbaceous plants, shrubs, and trees. This information will satisfy the requirements of production identification and also supply information that can be applied to more than one class of animal. It is intended that this forage capability classification system be applicable only to ungulates (both livestock and wildlife). However, such a wide variety of animals has a diversity of foraging habits, and virtually all herbaceous and shrubby vegetation may be consumed in varying amounts at some point in time. Therefore, all herbaceous plants and browse are considered as forage when determining production values. Lichens present some problems when being considered as forage, crustose lichens are too firmly affixed to the

substrate to be utilized as forage, and very little is known of the importance of foliose as forage. For the purpose of this classification only fruticose lichen (both arboreal and terrestrial growth forms) are considered as forage.

Three major types of forage are considered in the present forage classification - herbaceous plants, browse (low growing, woody plants) and fruticose lichens. Due to differences in growth and general life history of forage species, each forage type is sampled and rated separately. The groups can be directly related to the strata used in standardized collection of vegetation data (Walmsley et al., 1980). Herbaceous vegetation includes all species occurring in the herb (C) layer. Woody plants include all species found in the low shrub (B2) layer. Appendix A, Table 2 lists species that are classified as browse[1] species that are usually listed in the herb layer as defined by Walmsley et al., 1980, p. 141. Terrestrial lichens are all fruticose lichens occurring in the Moss (D) layer; and, arboreal lichens are all fruticose lichens occurring in the tree (A) or shrub (B) layers.

Forage production is determined by measuring the annual above ground growth of vegetation. It is not a measure of total production as it does not account for wood production, subterranean growth or plant tissue that disappears by weathering and decomposition. Most above ground biomass of herbaceous plants is annual growth. Production estimates for herbaceous

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[1] Browse - "that part of leaf and current twig growth of shrubs, woody vines, and trees available for annual consumption". (U.S. Forest Service, 1963).

Plate 7. Forage production is measured using two basic techniques: estimates of percent canopy coverage of an area occupied by shrubs, low trees and terrestrial lichens; and, the technique illustrated here of clipping and weighing the standing crop of herbs, grasses and sedges. Such clippings must be from carefully measured areas, in this case, an area that is exactly one square metre.

Plate 8. The measuring of forage production can employ various techniques; this one is the macroplot as described by Poulton and Tisdale (1961) and the ocular estimate of species canopy coverage in a tenth square metre recorded at regular intervals on randomly selected transects as described by Daubenmire (1968).

Photo credit: Canada Department of Agriculture

vegetation entails clipping all living above ground parts (avoiding dead, standing matter) from a given area and weighing the sample after oven-drying[1] at a constant temperature to attain comparable results. It seems impractical to use canopy coverage as a measurement of herb productivity, because herbaceous vegetation often forms a dense sward without necessarily having a high weight production.

Browse production can be determined by clipping, separating and weighing current annual leaves and stems. This procedure can be extremely time consuming, and is not practical for most reconnaissance level inventories. There appears to be a greater variation of percent canopy cover with shrubs than with herbs, especially on forested sites. Therefore, an alternative sampling procedure for the measurement of browse production, is canopy coverage estimates. This is obviously much faster than using a three dimensional classification or a method of clipping annual twig and leaf growth and then relating that measurement to surface area. Field experience has shown that annual biomass production on shrubs, especially those with a circular growth form, relates well with percent cover measurements.

Fruticose lichens are the third major forage type considered. Annual growth is usually very slow, and would be difficult to separate from previous year's growth. Therefore, productivity must be related to biomass without any specific limiting time scale. Terrestrial fruticose lichens are measured

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[1] The procedure of oven-drying might vary amongst scientists or laboratories - a recommended technique is drying at 55°C for 24 hours.

Plate 9. The measuring of forage production can be accomplished by combining techniques; a circle with a radius of 5.64 metres is being employed to count fecal groups and to assess shrub density and canopy coverage.

Plate 10. Arboreal lichens in conifer trees have presented special problems for conducting productivity measurements. In addition to normal growth requirements, arboreal lichens are also dependent on the type of tree species, tree density and number of branches in each tree.

by percent cover and are not clipped or weighed. Arboreal fruticose lichens are measured by the estimating the abundance of lichens and the abundance of the growing sites (tree trunks and branches) and thus the biomass (kilograms/hectare) of arboreal lichens can be estimated (see Stevenson, 1978 and 1979).

It is intended that the rangeland biophysical capability program be conducted at a general level of inventory, therefore, the classification is applied to a project area, on the basis of one year's extrapolated data. There will be a problem in obtaining values that relate to "normal" weather years from which to extrapolate to potential productivity values. Dry or wet years may provide non-typical values for extrapolation. Ideally there should be repeated sampling on representative sites over several years in order to obtain a set of long term data in which to relate the effects of weather on productivity. It is necessary to relate the data collected from the general surveys to existing long term data sources.

2.2 Forage Capability Classes

Five capability classes are described for the three types of native forage - lichens, herbaceous plants, and browse. The classes are defined on the basis of a range of either dry-weight of biomass per unit area or canopy coverage. The following are definitions of each class, in addition Table 1 provides a summary of each class.

Class 1 LANDS IN THIS CLASS HAVE VERY HIGH CAPABILITY TO PRODUCE THE ASSIGNED FORAGE TYPE

Capability to produce herbaceous plants, lichens, and/or browse on these units is very high. These units can produce 1000 to 2000 kilograms/hectare/year of herbage; or, can have a canopy coverage of 50 to 100 percent browse; or, can have a canopy coverage of 50 to 100 percent terrestrial lichens; or, can have a biomass of 1000 to 2000 kilograms/hectare of arboreal lichens.

Class 2 LANDS IN THIS CLASS HAVE HIGH CAPABILITY TO PRODUCE THE ASSIGNED FORAGE TYPE

Capability to produce herbaceous plants, lichens, and/or browse on these units is high. These units can produce 500 to 1000 kilograms/hectare/year of herbage; or, can have a canopy coverage of 25 to 50 percent browse; or, can have a canopy coverage of 25 to 50 percent terrestrial lichens; or, can have a biomass of 500 to 1000 kilograms/hectare of arboreal lichens.

Class 3 LANDS IN THIS CLASS HAVE MODERATE CAPABILITY TO PRODUCE THE ASSIGNED FORAGE TYPE

Capability to produce herbaceous plants, lichens, and/or browse on these units is moderate. These units can produce 225 to 500 kilograms/hectare/year of herbage; or, can have a canopy coverage of 10 to 25 percent browse; or, can have a canopy coverage of 10 to 25 percent terrestrial lichens; or, can have a biomass of 225 to 500 kilograms/hectare of arboreal lichens.

Class 4 LANDS IN THIS CLASS HAVE LOW CAPABILITY TO PRODUCE THE ASSIGNED FORAGE TYPE

Capability to produce herbaceous plants, lichens, and/or browse on these units is low. These units can produce 110 to 225 kilograms/hectare/year of herbage; or, can have a canopy coverage of 5 to 10 percent browse; or, can have a canopy coverage of 5 to 10 percent terrestrial lichens; or, can have a biomass of 100 to 225 kilograms/hectare of arboreal lichens.

Class 5 LANDS IN THIS CLASS HAVE VERY LOW TO NO CAPABILITY TO PRODUCE THE ASSIGNED FORAGE TYPE

Capability to produce herbaceous plants, lichens, and/or browse on these units is very low to none. These units can produce 0 to 110 kilograms/hectare/year of herbage; or, can have a canopy coverage of 0 to 10 percent browse; or, can have a canopy coverage of 0 to 10 percent ground lichens; or, can have a biomass of 0-110 kilograms/hectare of arboreal lichens.

Table 1: Production range for forage types for each capability class

Forage Type	Capability Class				
	1	2	3	4	5
Herbaceous Vegetation (Kilograms/hectare/year)	1000-2000+	500-1000	225-500	110-225	0-110
Woody Vegetation (% canopy coverage)	50-100	25-50	10-25	5-10	0-5
Terrestrial Lichens (% canopy coverage)	50-100	25-50	10-25	5-10	0-5
Arboreal Lichens (kilograms/hectare)	1000-2000+	500-1000	225-500	110-225	0-110

Chapter 3
APPLICATION OF THE FORAGE CAPABILITY SYSTEM

3.1 Introduction

Forage levels and species composition vary with successional stage due to competition for sunlight, moisture and nutrients. When the forest canopy is removed by fire or logging, the dominant vegetation becomes established with shade intolerant grasses and forbs. Taking longer to become established, shade intolerant shrubs and deciduous trees become dominant some time after the tree canopy has been removed. Conifer trees, generally, become established after the shrubs. Once the trees attain dominance, competition for moisture and sunlight becomes critical and the shrubs and herbs that grow best in open sites die out. As the emerging forest matures the number of trees are reduced and the canopy becomes more open, and at the same time herbs and shrubs that can grow under a closed canopy become established. Finally, when the forest reaches a climax state and over-mature trees die and open the canopy to further tree regeneration, an understory composed of a mixture of shade tolerant and shade intolerant herbs and shrubs with moderate light requirements become established.

A capability rating can be applied to the forage production ability of any site for any stage of succession. For the purpose of this classification

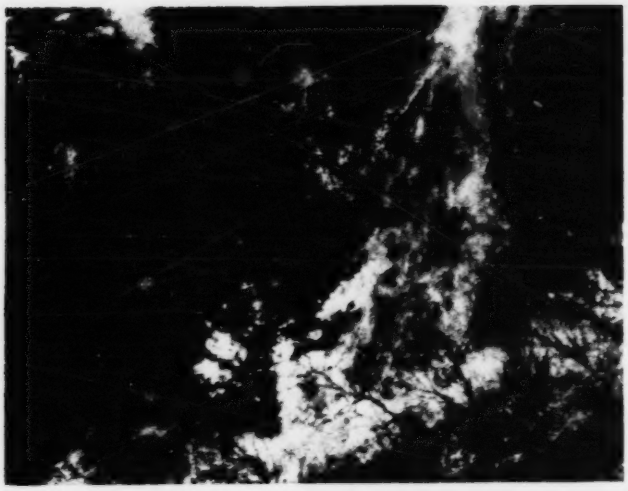

Plate 11. Fire is an important tool in increasing herbage production and reducing competition from trees. Although wildfires are no longer an acceptable force in British Columbia, more and more rangelands are being managed by deliberately set and controlled fires.

Plate 12. The removal of the forage canopy by fire has the affect of increasing herb and shrub production and it has the affect of increasing the habitat for ungulates that require open grassland-like areas for foraging. The forage capability of this site is high in this post-burned stage, but it is low in the forest dominated stage.

Photo credit: B.E.Clapp

forage capability will be based on the successional stage that yields the highest forage production for the given class of forage (herbaceous, woody or lichen vegetation). Herbage production is probably highest at or near the climax stage, in grassland or alpine environments; but in forested environments maximum herbage production is probably some early stage after tree removal and prior to tree re-establishment.

However, because much of the province is under forest, it is useful to understand the forage production potential of forests. Therefore, on treed sites, potential will be considered at two stages:

1. after tree removal by either logging or fire and prior to tree dominance[1]. The exact timing of the most productive stage for forage is to be at the point in time that the unit can be maintained in the treeless state.

2. at or near rotation age of the forests or when the trees become mature. The precise period of time for the various areas and types of stands being the standards set by the British Columbia Ministry of Forests (B.C. Forest Service, 1976).

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[1] Dominance is based primarily on abundance. Dominant species have a high cover value in a plot; may be taller than other species within the same layer; (Harcombe, 1978).

Plate 13. Logging and slash burning can play a dominant role in increasing herb and shrub production. These forest sites will be rated for their forage production once the herb and shrub production has stabilized in a few years and again as a mature forest dominated site.

Plate 14. High grass and herb production can be maintained through proper livestock manipulation and control. Deferred grazing is one such scheme that will ensure proper grazing levels; these steers are being moved out of this pasture now that the proper grazing level of Idaho fescue has been achieved.

For special purposes a further option remains, and that is to rate the forage production potential of each successional stage of a forest stand. Such a program will provide more information to the forage managers on the dynamics of forage production. Such a classification will probably be more suited to a map narrative or as an attribute in a table of stand characteristics than as a mappable item.

3.2 Forage Types

The three forage types can be further detailed. The herbaceous type may be subdivided into grasses, sedges and rushes (grasslike plants) and forbs. Grasses include all members of the family Poaceae (formerly Graminae); sedges and rushes include all members of the families Cyperaceae and Juncaceae; and, forbs would include all members of the remaining families of monocots and dicots that contain flowering plants without persistent woody stems above ground (doubtful plants are listed in Appendix A, Table 3). The browse forage type may be divided into shrubs, deciduous trees and coniferous trees (doubtful plants are listed in Appendix A, Table 2). The lichen type may be subdivided into arboreal and terrestrial fruticose lichens.

The sample legend (Figure 1) gives the appropriate symbols for the above forage types - general or specific. For practical purposes, a capability class rating for terrestrial lichens is only provided in geographical areas where the lichens would be considered to be an important ungulate food (e.g. caribou ranges).

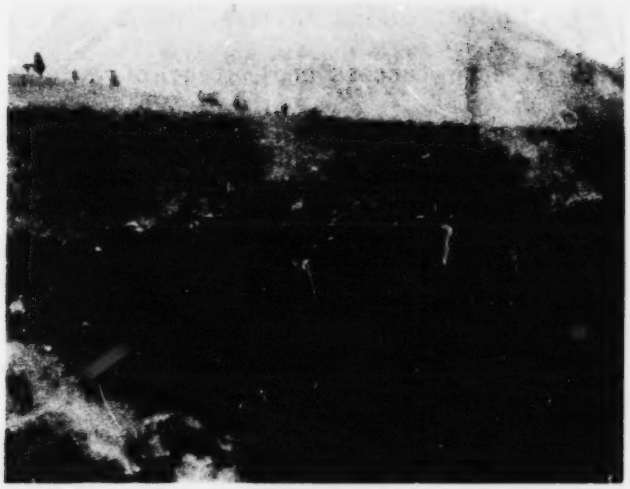


Plate 15. Prescribed burning is an effective tool for rejuvenating decadent shrub stands, and for increasing herbage production. This site has the ability to produce trees, but, with judicious use of fire and with livestock and wildlife management it has a high capability to produce shrubs, grasses and forbs.

Plate 16. Fire applied during the dormant late winter period will only kill the above ground portions of shrubs and herbs. This bitterbrush plant is sprouting within weeks of its crown being burned.

3.3 Environmental Conditions

Capability maps often list limiting subclasses in conjunction with the capability class rating. This implies that this limiting factor prevents the rating from attaining the higher rating based on regional climate and physical site characteristics.

However, wildlife (ungulate) capability mapping links the class ratings with environmental conditions rather than with limiting subclasses. These environmental conditions are also used in forage capability mapping. The conditions are defined as factors of the environment that have a significant influence on the production of forage and thus on the capability rating. These environmental conditions affect the ability of the land to produce forage, either as favourable or as unfavourable limiting factors. For convenience, the environmental conditions are described and symbolled in three main categories; those relating to climate (such as temperature and snowfall), those relating to the inherent characteristics of the land (such as landforms, soils or vegetation potential) and those relating to permanent anthropogenic (man-made) changes to the land base. This listing is not restricted to those conditions described - it may be expanded or reduced to reflect both the characteristics of the project area and the scale of the project. Figure 1 (Box 5) lists map symbols and definitions for some environmental conditions.

3.4 Mapping Conventions

Forage capability can be mapped at any number of scales and for one or more of the forage types. The Terrestrial Studies Branch has mapped forage capability at 1:50 000 on vegetation landscape base maps. In addition to the capability class, map units may provide more detail on forage type and on environmental conditions found within the unit. There are also a set of mapping guidelines or conventions that have been developed to provide consistency of approach.

Two examples of forage capability maps have been included in this report. Figure 2 represents a map of an area that is dominantly a wetland/-forest complex of landscapes. Figure 3 represents a map from an area dominated by a dry grassland/forest complex of landscape. Because lichens are neither dominant nor an important forage species in either area, only herbaceous and browse forage types have been rated.

The following is a brief list of mapping conventions used in forage capability mapping. These conventions apply to the use of five capability classes rated for each of the three forage types. They may or may not be illustrated on the same map - lichen capability could be separated from woody plant capability which could be separated from herbaceous plant capability.

1. Capability classes are shown in Arabic numerals (see Figure 1).
2. Forage types are shown in upper case letters and listed in decreasing order of dominance; they will not be separated by any

Plate 17. Grasslands in British Columbia are dominated by grasses, forbs, and sometimes shrubs, conifer trees grow only in the shaded or moist draws. Sites with this class of vegetation will be rated only at the climax community stage.

Plate 18. In alpine areas as in grasslands the forage production is only rated at the climax community stage. This site indicates the reason why the canopy coverage method for rating shrub production is not feasible for rating the productivity of herbs. This site has nearly 75 percent canopy coverage and yet it is producing less than 500 kilograms per hectare per year.

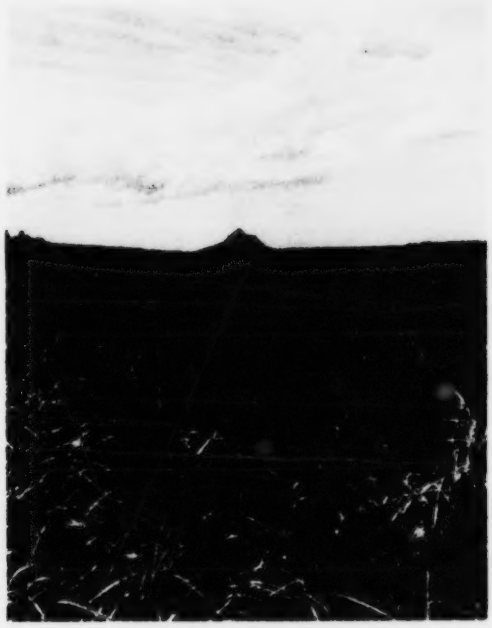


Plate 19. A sedge meadow such as this one will only be rated at the climax community stage.

Plate 20. Krummholz forest/alpine transition site. These sites present special mapping difficulties due to the contrasting forage production in the forests versus the alpine areas. Units that are dominantly alpine in structure should only be rated at the climax community stage while units that are dominantly forest in structure should be rated at the cleared stage and again at the mature forest stage.

symbol such as a comma or slash; a maximum of two special class indicators shall be listed for each capability class (see Figure 2 and 3).

3. Environmental conditions are shown in upper and lower case letters (Figure 1); they are placed under the capability class numeral and separated from the class by a horizontal line; a maximum of three environmental conditions will be used; where two or three conditions are desired, they are listed in decreasing order of importance; they will not be separated by any symbol such as a comma or slash.

4. If the capability ratings are being assigned to a map polygon that is a complex of biophysical units, the ratings are:

   a) averaged for the polygon, giving only a single capability rating per forage type

   b) complexed, where each set of capabilities is separated by a vertical line and a proportion out of ten is assigned as a superscript (see Box 2, Figure 1).

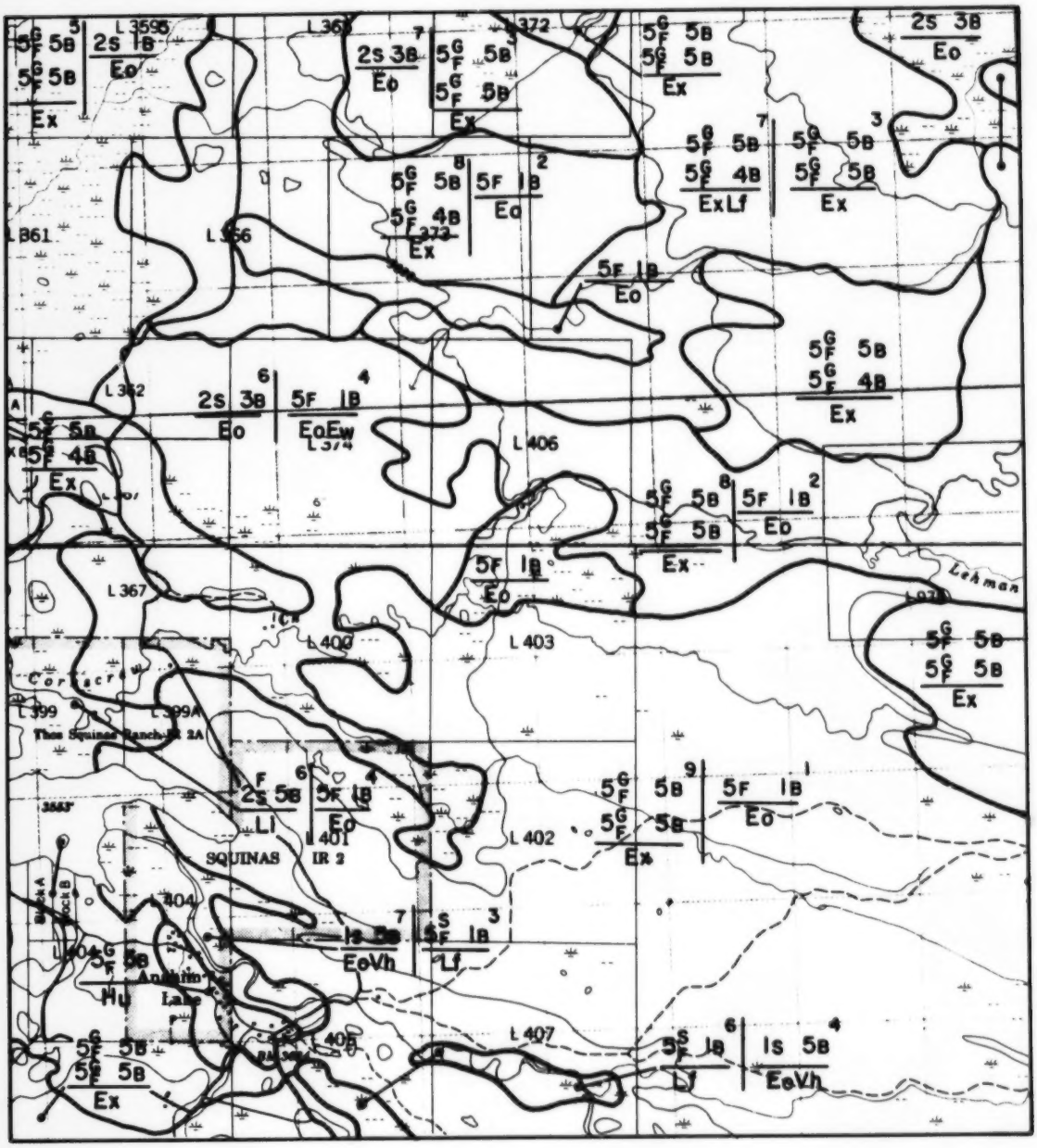


Figure 2: Forage Capability Map - Wetland/Forest Complex

Figure 1 Forage Capability Map Legend

1. Explanatory Notes

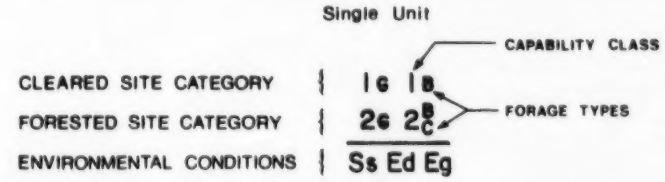
This map represents a biophysical classification for forage capability (see Box 8). Like capability maps for forestry, wildlife, and agriculture, forage capability maps are based on landforms, surficial materials, soils, climate and vegetation that are considered to form "ecologically significant" units of land.

The capability of the land to produce native forage is based on the optimum vegetational (successional) stage that can be maintained. Management prescriptions are limited to prescribed burning, grazing, or prescribed logging, thinning or slashing. This capability classification reflects only the biological and physical parameters of the environment and does not take into account social and economic factors. Also, the classification does not reflect present land use (except where the inherent capability has been permanently altered), ownership, and degree of access.

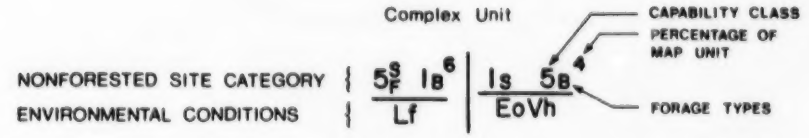
Forage, for the purposes of this capability classification, is considered to include all native or wild growing plant species that may be used as a food source for (livestock or wildlife). Forage includes herbaceous plants, shrubs, low trees and fruticose lichens.

2. Examples of Map Symbols

a) Forested units are rated for herbaceous and woody plants and fruticose lichens as cleared sites and as forested sites at or near rotation age (maturing seral):



b) Nonforested units are rated for herbaceous and woody plants and terrestrial lichens at a climax stage only:



3. Capability Classes

CLASS 1 Lands in this class have very high capability to produce the assigned forage type.

CLASS 2 Lands in this class have high capability to produce the assigned forage type.

CLASS 3 Lands in this class have moderate capability to produce the assigned forage type.

CLASS 4 Lands in this class have low capability to produce the assigned forage type.

CLASS 5 Lands in this class have very low to no capability to produce the assigned forage type.

4. Production range for forage types for each capability class

Forage Type	Capability Class				
	1	2	3	4	5
Herbaceous Vegetation (Kilograms/hectare/ year)	1000-2000+	500-1000	225-500	110-225	0-110
Woody Vegetation (% canopy coverage)	50-100	25-50	10-25	5-10	0-5
Terrestrial Lichens (% canopy coverage)	50-100	25-50	10-25	5-10	0-5
Arboreal Lichens (kilograms/hectare)	1000-2000+	500-1000	225-500	110-225	0-110

5. Forage Types

Capability is rated for each of three major types of forage: herbaceous plants, woody plants, and lichens[1]. Further subdivision of forage type may also be included.

H..... herbaceous plants
- F.... forbs
- G.... grasses
- S.... sedges

W.... woody plants
- B.... shrubs
- C.... conifer trees
- D.... deciduous trees

L.... lichens
- T.... terrestrial fruticose lichens
- A.... arboreal fruticose lichens

[1] Lichens are only rated where they are an important food source.

6. Environmental Conditions

The most significant environmental conditions influencing the production of native forage and thus determining the capability class, are indicated on the map. The environmental condition symbols are placed in three main categories: those relating to climate (such as temperature or exposure), those relating to the inherent characteristics of the land (such as landforms, soils or vegetation), and those relating to permanent anthropogenic (man-made) changes to the land base.

CLIMATIC

Pa - RAIN SHADOW - unit in which more xeric-tolerant plants become established due to climatic factors than in adjacent areas

Sp - SNOWFIELDS AND GLACIERS - unit of permanent ice or snow

Ss - INTENSIFIED SOLAR RADIATION - unit in which snow accumulation is significantly reduced through exposure to solar radiation on southerly aspects

Sw - WINDSWEPT SNOW - unit in which snow accumulation is considerably reduced by wind erosion

Ta - ALPINE ARIDITY - unit at high elevations that is subject to aridity in summer from extreme evapotranspiration and wind action

Tc - COLD AIR LAYER - extreme and persistent freezing temperatures below temperature inversions

Tf - FROST POCKETS - unit that is subject to increased occurrence of freezing temperatures relative to the surrounding terrain

Th - HIGH HEAT - unit that is subject to high heat causing extreme evapotranspiration

Tw - WARM AIR LAYER - relatively warm air, occurring over temperature inversions

We - EXPOSURE - unit that is greatly exposed to local winds throughout the year

(continued on next page)

6. Environmental Conditions (Continued)

ECOLOGICAL

Ea - ALKALINE SOILS - unit of strongly alkaline soil

Eb - STONY SOILS - unit dominated by a soil with a stoniness phase of very stony to excessively stony

Eg - WET SOILS - unit dominated by mineral soils that are excessively wet from seepage or high water table as evidenced by soil gleying

Eh - MOIST SOIL - unit dominated by moister-than-average mineral soil

El - DEEP LACUSTRINE DEPOSITS - unit dominated by soils developed from deep, inactive lacustrine

Eo - ORGANIC SOILS - unit dominated by poor drainage and organic soils

Er - BEDROCK - unit that is dominated by bedrock

Es - SALINE SOILS - unit of strongly saline soil

Et - TALUS - unit that is dominated by talus

Ew - DEEP FLUVIAL DEPOSITS - unit that is dominated by well to rapidly drained soils developed from deep, inactive fluvial deposits

Ex - DRY SOIL - unit that is dominated by well to rapidly drained soils of coarse textured morainal or colluvial materials

La - AVALANCHE TRACTS - unit that has avalanche chutes

Le - SOIL EROSION - unit that has erosion or potential erosion ranging from sheet erosion through to minor gulleying

Lf - ACTIVE FLOODPLAIN - unit of flat land bordering a river and subject to periodic flooding

Li - FRESH WATER INUNDATION - unit that is subject to long periods of natural flooding resulting in marshy vegetation

Lo - OPEN WATER - unit that is permanently covered with standing water

Lt - TIDAL INUNDATION - unit that is flooded frequently by tidal activity

Lw - FAILING SLOPES - unit of extensive slope movement

Vh - HERBACEOUS COMPETITION - unit dominated by herbaceous community that is seriously impeding productivity of shrubs or trees

Vs - SHRUB COMPETITION - unit dominated by shrub community that is seriously impeding productivity of herbaceous plants or trees

Vt - TREE COMPETITION - unit dominated by tree community that is seriously impeding productivity of herbaceous plants or shrubs

(continued on next page)

6. Environmental Conditions (Continued)

ANTHROPOGENIC

Hc - CULTIVATED LAND - unit of intensive cultivation that has permanently altered native forage potential

Hh - RESERVOIR DRAW-DOWN ZONE - the area between full pool and low pool in reservoirs

Hi - INDUSTRIAL DEVELOPMENT - unit of industrial development such as mills, mines, tailings, or spoil areas

Hr - TRANSPORTATION CORRIDORS - unit that has a significant proportion of transportation development such as roads, railroads or pipelines.

Hu - URBAN DEVELOPMENT - unit that has permanent urban development

7. Sources of Information

a) B.C. Ministry of Environment, Terrestrial Studies Branch

i) Terrain maps - 19__
ii) Forest Zonation/Present Ecological Condition maps - 19__
iii) Forage productivity survey (19__) - __ plots

b) B.C. Ministry of Environment, Surveys and Mapping Branch

i) scale of aerial photographs - 1:_____
ii) date of photography - _____

8. For Further Information

a) References:

1) Biophysical Forage Capability Classification, Terrestrial Studies Branch, Victoria, B.C., 1981.

b) Additional data and more detailed information is available from:

Operations Manager
Terrestrial Studies Branch
Ministry of Environment
Parliament Buildings
Victoria, B.C. V8V 1X4

c) Additional forage capability maps available from:

Map Library
Terrestrial Studies Branch
Ministry of Environment
Parliament Buildings
Victoria, B.C. V8V 1X4

9. Credits

Mapping supervised by _____

Date of field mapping ____

Drafted by Cartography Unit, Terrestrial Studies Branch, Ministry of Environment, Victoria, B.C.

Date of mapping ____

Revision dates _____

Base map provided by Surveys and Mapping Branch, Ministry of Environment, Victoria, B.C.

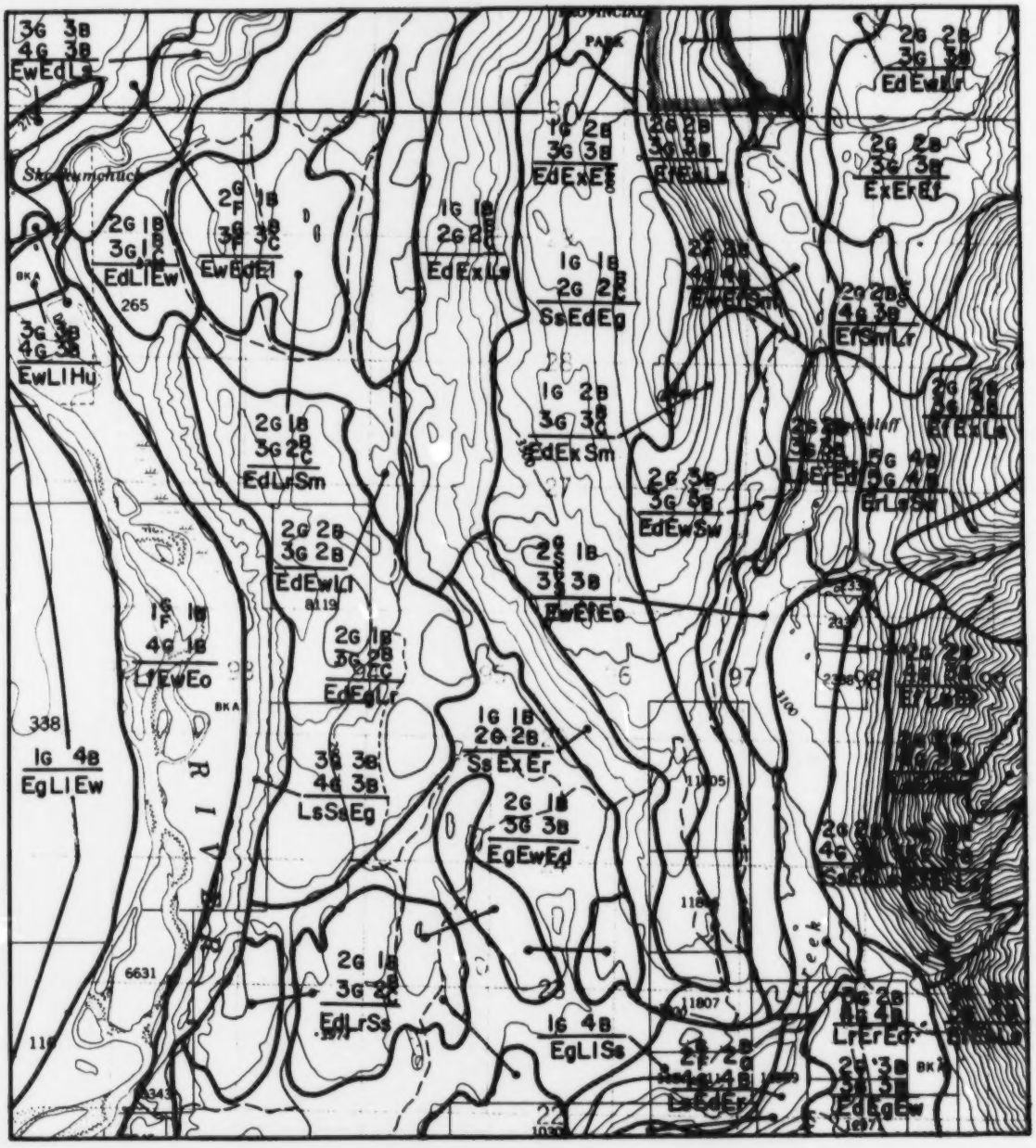


Figure 3: Forage Capability Map - Grassland/Forest Complex

Plate 21. A forest/grassland transition site. These sites present special mapping difficulties when either the forests or the grasslands are too small to be mapped separately. It is recommended that small sites be rated at the cleared or grassland stage and at the mature forest stage when forest dominates the area as in this photo.

Plate 22. A Ponderosa pine - rubber rabbit brush-bluebunch wheatgrass dominated site that has achieved a high herbage productivity in spite of the forest canopy. However, the forage levels should be rated both at this mature forest stage and at a tree-removed stage.

Photo credit: Canada Department of Agriculture

Plate 23. A trembling aspen-rose dominated site that has achieved a high browse production level. However, this site should also be rated as a mature conifer dominated forest.

Plate 24. A cedar-hemlock forest with various tree, shrub and herb layers demonstrates the difficulty that would arise if clipping and weighing were necessary in order to rate production of browse rather than a rating system that relied on canopy coverage estimates.

3.5 Recording Data In The Field

The Ministries of Environment and Forests have a series of site, soils, vegetation and wildlife description forms for recording forage production and related site description information. For details and user instruction for these forms see Walmsley et al (1980) and Sondheim and Vold (in press).

The vegetation description form is designed for forage production assessment. Canopy coverage estimates in percent for browse species are to be coded in the Low Shrub (B2) Section (Columns 33 and 34). Similarly, canopy coverage estimates in percent for terrestrial fruticose lichen species are to be coded in the Moss/Lichen (D) Section (Columns 45 and 46). In the Forage Section, columns 65-67 are used to record the actual weight in grams per square meter of any plant species or group of plant species ie. grasses, sedges, forbs; and, column 68 is used to record the code for the particular method used ie. Code 1 - estimated green weight, Code 2 - estimated air dried weight, Code 3 - estimated oven dried weight, Code 4 - measured green weight, Code 5 - measured air dried weight, and Code 6 - measured oven dried weight.

Note that the recording of production information at a given site is a measure of existing values, this data must be further interpreted to rate capability. Also, the vegetation description form cannot accommodate the capability ratings because the forage capability classification does not relate to a given point in succession or management level.

Chapter 4
SUMMARY

The following points summarize the highlights of the forage capability classification methodology:

1. The separation of the land surface into repeatable ecological units is based on the basis of the physical and biological characteristics of the terrain, soil, and vegetation.

2. Each unit is assigned to a class on the basis of all known or inferred information about the unit, including soil, parameters, surficial materials, climate, and vegetation.

3. Capability for herbaceous plant production is considered as the maximum annual dry matter production of herbage that can be sustained on a biophysical unit under assumed management practices; capability for woody plant production will be considered to be the maximum canopy coverage of shrubs that can be sustained on a biophysical unit under defined management practices; capability for terrestrial lichen production will be considered to be the maximum canopy coverage of lichens that can be sustained on a biophysical unit under defined management practices; and capability for arboreal lichen production will be considered to be the maximum abundance of lichens that can be sustained on a biophysical unit under defined management practices.

4. Each biophysical unit may be rated for its capability to produce herbs, for its capability to produce shrubs and for its capability to produce lichens. Non-forested sites (i.e. grasslands and alpine) are rated for herbs, shrubs, and/or lichens only once at maximum sustained forage productivity. Forested sites are rated for herbs, shrubs and/or lichens twice; firstly as a tree-removed site at maximum sustained forage productivity and secondly as a forest dominated site at or near rotation age or tree maturity.

5. Herbaceous plants will be rated on an annual production basis i.e. kilograms/hectare/year (oven-dried). Arboreal lichens will be rated on a biomass basis, i.e. kilograms/hectare (oven-dried). Woody plants and terrestrial lichens will be rated on a percent canopy coverage basis. Terrestrial lichens will only be rated in areas where they are considered to be important as an ungulate food source. Table 1 shows the production range for each capability class.

6. The capability classification will be based mainly on the "natural state" of the land without improvements such as fertilization, drainage, irrigation or introduction of exotic plant species.

7. In a given capability class, location, access, distance to markets and size of units will not be considered.

8. Access to water, salt, cover and other rangelands while important to livestock and wildlife management, cannot be realistically appraised at this time, so will not be considered in this classification.

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Taylor, Roy L. and Bruce MacBryde. 1977. Vascular Plants of British Columbia: A Descriptive Resource Inventory. Technical Bulletin No. 4. The Botanical Garden. University of British Columbia, Vancouver, B.C.

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Walmsley, M.E. and J. van Barneveld. 1977. Biophysical land classification techniques: the application to ecological classification of forest land in British Columbia. Pages 41-119. In Proceedings Ecological classification of forest land in Canada and Northwestern U.S.A. Center of Cont. Education, University of British Columbia, Vancouver, B.C. 395 pp.

Appendix A
LISTS OF PROBLEMATIC SPECIES

Table 2: Low woody plants[1] that are to be considered in woody plant forage type

Andromeda polifolia	bog rosemary
Arctostaphylos alpina	alpine manzanita
Arctostaphylos rubra	red manzanita
Arctostaphylos uva-ursi	kinnikinnick
Cassiope lycopodioides	club-moss cassiope
Cassiope mertensiana	Mertens' cassiope
Cassiope stelleriana	Steller's cassiope
Cassiope tetragona	four-angled cassiope
Chimaphila menziesii	Menzies' pipsissewa
Chimaphila umbellata	common western pipsissewa
Empetrum nigrum	black crowberry
Gaultheria humifusa	alpine-wintergreen
Gaultheria hispidula	creeping-snowberry
Gaultheria ovatifolia	Oregon-wintergreen
Loiseleuria procumbens	alpine-azalea
Penstemon davidsonii	Davidson's penstemon
Penstemon ellipticus	elliptic-leaved penstemon
Phyllodoce empetriformis	red mountain-heather
Phyllodoce glanduliflora	cream mountain-heather
Polygonum cuspidatum	Japanese knotweed
Polygonum paronychia	beach knotweed
Polygonum polystachyum	Himalayan fleeceflower
Polygonum sachalinense	giant knotweed
Rhododendron lapponicum	lapland rhododendron
Rubus nivalis	snow dewberry
Rubus ursinus	Pacific trailing blackberry
Salix arctica	Arctic willow
Salix cascadensis	cascade willow
Salix polaris	polar willow
Salix reticulata	net-leaved dwarf willow
Salix stolonifera	stoloniferous willow
Vaccinium caespitosum	dwarf blueberry
Vaccinium scoparium	grouseberry
Vaccinium vitis-idaea	mountain cranberry
Vaccinium myrtillus	low bilberry

[1] Nomenclature follows Taylor and MacBryde (1977).

Table 3: Low woody plants and species of doubtful lifeform[1] that are considered in herbaceous plant forage type

Anemone multifida	Pacific anemone
Apocynum androsaemifolium	spreading dogbane
Apocynum cannabinum	Indian-hemp dogbane
Apocynum pumilum	mountain dogbane
Apocynum sibiricum	clasping-leaved dogbane
Artemesia frigida	prairie sagebrush
Aruncus dioicus	sylvan goat's beard
Asclepias ovalifolia	oval-leaved milkweed
Asclepias speciosa	showy milkweed
Chamaerhodos erecta	American chamaerhodos
Comandra umbellata	pale comandra
Cornus canadensis	Canadian bunchberry
Cornus suecica	dwarf bog bunchberry
Cornus unalaschkensis	western Cordilleran bunchberry
Draba spp.	whitlow-grasses
Dryas drummondii	yellow mountain-avens
Dryas integrifolia	entire-leaved white mountain-avens
Dryas octopetala	white mountain-avens
Eriogonum androsaceum	alpine umbrellaplant
Eriogonum flavum	yellow umbrellaplant
Eriogonum heracleoides	parsnip-flowered umbrellaplant
Eriogonum niveum	snow umbrellaplant
Eriogonum ovalifolium	oval-leaved umbrellaplant
Eriogonum pauciflorum	few-flowered umbrellaplant
Eriogonum umbellatum	sulphur-flowered umbrellaplant

[1] Nomenclature follows Taylor and MacBryde (1977).

Table 3 (Continued)

Fragaria chiloensis	Pacific coast strawberry
Fragaria vesca	wood strawberry
Fragaria virginiana	blue-leaved wild strawberry
Galium boreale	northern bedstraw
Geocaulon lividum	northern red-fruited comandra
Kalmia microphylla	western swamp kalmia
Linnaea borealis	northern twinflower
Lithospermum incisum	yellow gromwell
Lithospermum ruderale	Columbia gromwell
Luetkea pectinata	luetkea
Orthilia secunda	one-sided wintergreen
Phlox caespitosa	tufted phlox
Pyrola spp.	pyrolas
Rubus arcticus	dwarf nagoon berry
Rubus chamaemorus	cloudberry
Rubus lasiococcus	dwarf bramble
Rubus pedatus	five-leaved creeping raspberry
Saxifraga bronchialis	prickly saxifrage
Saxifraga cespitos	tufted saxifrage
Saxifraga flagellaris	stoloniferous saxifrage
Saxifraga oppositifolia	purple mountain saxifrage
Saxifraga tricuspidata	three-toothed saxifrage
Sibbaldia procumbens	creeping sibbaldia
Vaccinium oxycoccos	bog cranberry

Appendix B
FIELD METHODS

B.1 Introduction

It is not our intention to provide a complete list of quantitative plant ecology methods nor to restrict the approach to one or two favoured methods. In the first case there are several textbooks, symposia and bibliographies that more than adequately discuss the subject, and, in the second case there are several methods which will satisfy the objectives. However, we will provide several references that discuss quantitative plant ecology, plus, we will discuss our interpretation of plot selection, canopy coverage, and forage production.

B.2 Selected Bibliography

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B.3 Plot Selection

The following method of plot selection is the one used by the Terrestrial Studies Branch and is quoted from Walmsley et al. (1980):

> "When choosing sites to describe, the objectives of sampling must be clearly understood. In some cases random location of sites may be the requirement, but in most cases sites are chosen to represent mapping units, or to cover a specified range or combination of properties. In this case, a clear statement as to the nature of criteria and features used is necessary.
>
> "Sample plots should be homogeneous in soil and vegetation properties. Contrasting soil types in a vegetation plot or contrasting vegetation types in a soil plot are to be avoided. Where repetitive or cyclic patterns occur over short distances, for example gullied or hummocky terrain, uniformity of plot conditions may be maintained by adjusting the shape of the boundaries."
>
> "Plot location in the field requires an evaluation of four main factors: representativeness, replication, areal extent, and homogeneity. Each prospective sampling area is generally chosen to represent a defined set of environmental conditions. The field examination should confirm these conditions; or, if conditions vary from those anticipated, a decision must be made on the merit of sampling the conditions encountered."

"Within the plot area, environmental conditions should be relatively homogeneous. The plot should usually include a single soil polypedon and a single plant community, and be homogeneous with respect to environmental factors such as slope position, landform, texture, soil drainage, species composition or dominance, physiognomy, and stand structure. Areas which include two easily distinguishable soil or vegetation types should be avoided.

"Cyclic or repetitive variation must be evaluated relative to the size of each type and the size of the sample plot. For example, variation due to hummocky microtopography cannot be separated into two plots (e.g. tussock in fen), whereas a series of rolling ridges can be separated by using elongated plots.

"Sampling too close to roads, buildings, fence rows, etc., can often produce misleading information, since such sites represent abnormal conditions. Sampling too close to a gravel road, for example, can reflect the influence of significant road dust, road drainage, and microclimatic influences. On the other hand, where past management practices have altered soil and/or vegetation properties over large areas, they should be described".

B.4 Selected Definitions

The following terms and definitions have been extracted directly from Daubenmire (1968):

1. Coverage - "Coverage is taken as an expression of the percentage of the ground included in a vertical projection of imaginary polygons drawn about the total natural spread of foliage of the individuals of a species. Since dominance is asserted as much by the roots as by the shoot system, and underground parts tend to be at least as extensive as the latter, there is little point in subtracting from the gross canopy coverage small discontinuities that reflect no more than accidents in the positions of foliage sprays, orientation of leaf blades, or peculiarities of phyllotaxy (the arrangement of leaves on a stem). The aim is to estimate the two-dimensional area that is directly influenced by the individual of each species."

"Usually some system of estimation is used in gathering coverage data, and if this is properly done, it gives results as accurate as vegetational heterogeneity warrants. Some investigators estimate coverage in a series of unequal classes (Vestal, 1943) such as those in Table 4."

Table 4: Values for a Coverage Estimation Technique

Coverage Class	Range of Coverage, %	Midpoint of Coverage Class, %
1	0-5	2.5
2	5-25	15
3	25-50	37.5
4	50-75	62.5
5	75-95	85
6	95-100	97.5

"One may apply this method simply by estimating the value for each species in a single plot (e.g. 10 x 10 meter), and such estimates are satisfactory for the purpose of characterizing stands and grouping them into associations (Hanson and Dahl, 1957).

"Coverage is determined separately for each species overlapping the plot regardless of where the individuals are rooted and regardless of superimposed canopies of different species, but ignoring intraspecific overlap. Since the canopies of different species are commonly interlaced, and those of different stature are commonly superimposed over the same area, the sums of coverages for a stand commonly exceed 100 percent. Where it is desirable to know the percentage of bare ground or the coverage of separate layers, special estimates of these can be made when tallying the species individually.

"With dominance (as with density) the absolute percentages (or numbers) are more meaningful than the relative ratings of the taxa. It is more important to know that a species has 12 percent coverage in a stand than that it provides 75 percent of the total plant cover. Only the absolute values give an insight in the capacity of the environment to support vegetation. If they are stated, the relative values can always be calculated if needed.

"Coverage, since its introduction into North America synecology by H.L. Shantz in 1906, has come to be considered a highly significant concept. It serves as a criterion of relative dominance, of potential productivity, of the influence of plants on precipitation interception and soil temperature and of the value of vegetation to animals. It is applicable to almost all phytocoenoses, owing to the universal importance of light coming from above. Not the least of its virtues is that it permits comparison on a common basis of all plants from mosses to trees since the different-sized plots that must be used for different-sized plants have no influence on the data. Finally, evaluations precise enough for research purposes do not require excessive field time."

"The chief limitation of coverage lies in omission of the vertical dimension, and while attempts have been made to weigh coverage data with a height factor (Evans and Jones, 1958) height is far more difficult to account for than might be suspected (Heady, 1957). The height problems can be lessened by grouping species according to layers when the data are tabulated."

2. Productivity - "Primary productivity refers to the weight of dry matter produced in a given period by all the green plants growing in a given space. Gross primary production is the amount actually produced, but all we can measure is net primary production, a lower value owing to respiratory use by the plants while they are producing. Ideally, net primary production should include roots (Bray, 1963) as well as shoots, since from a low percentage to 85 percent of the dry weight of a green plant may be underground, but in practice attention is usually restricted to shoots (stems + leaves + flowers + fruits + seeds). When primary productivity is used as a measure of dominance, attention is focused on the yearly production of the different associated species. Its use in this connection implies that species producing the most dry matter are exerting the most influence on the ecosystem, with dominants channeling a greater share of environmental resources into their own bodies and largely determining the amount, character, and timing of litter cast."

"The dry weight of herbs is commonly determined by laying out a plot, clipping all shoot material to the ground surface at one or more dates that allow an evaluation of each species at approximately the time it attains maximum dry weight, and discarding dead stalks left from the preceding year's growth. Fresh weight of living plant tissue is of limited value owing to wide differences in degree of hydration throughout the day and season. Therefore, the clipped material is usually air-dried quickly to minimize respiration loss, then dessicated to constant weight at 50-55°C so that dominance can be expressed as grams of ovendry material per square meter."

"The use of productivity as a measure of dominance has an advantage in that it allows differentiation among species having equal coverage or basal area but different amounts of shoot tissue as a result of variation in height or denseness of foliage."

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